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Evaluation Report

Evaluation of the

1982 Spruce Budworm

Suppression Projects

on Maine Indian

Trust Lands

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EVALUATION OF THE 1982 SPRUCE BUDWORM SUPPRESSION PROJECTS
ON MAINE INDIAN TRUST LANDS

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Introduction

In early June, 1982, both the Penobscot and Passamaquoddy Indian Nations of Maine conducted suppression projects to control spruce budworm on some of their trust lands (lands held in trust for the Nations by the Federal Government). The Penobscot Nation treated most of Alder Stream Township in western Maine (Franklin County), a total of 15,000 acres. The Passamaquoddy Tribe treated 2,000 acres in T5ND in eastern Maine (Washington County). Both Nations used Dipel® 4L, a formulation of Bacillus thuringiensis (Bt), applied by helicopter at 12 BIU's per acre.

The projects were conducted by personnel of the tribal forestry departments and their contractors, including the Dead River Corporation. The USDA Forest Service, Durham Field Office (then Portsmouth Field Office) provided technical assistance including help in planning the projects, on-site monitoring of insect development, aircraft calibration and characterization, and the evaluation described here.

The T5ND (Passamaquoddy) project was conducted June 1-4, 1982. The forest protected consists of spruce (mostly red spruce, Picea rubens) and eastern hemlock in an approximately 50-50 ratio. Because the insect development coincided with hemlock shoot development and was ahead of spruce shoot development, personnel of the Passamaquoddy Forest Department decided on budworm (fourth instar) on the hemlock as the target.

Alder Stream Township (Penobscot) was sprayed June 9-15. The objective was to protect spruce. Foliage flush at the lower elevations occurred 3-5 days before that at the higher elevations, so stands in the lower elevations were sprayed first. During the spraying at higher elevations budworm development was somewhat ahead of foliage flush, making proper timing of the spraying difficult. However, most areas were sprayed before most of the budworm reached the fifth instar.

The objective of the evaluation described here was to determine the effectiveness of the project, thus providing a basis for improving future projects. The evaluation methods are also critiqued.

Methods

For treatment purposes, both the T5ND and Alder Stream areas were divided into spray blocks. Block boundaries were roads, streams, and other topographic features recognizable from the air. The T5ND area was divided into 3 spray blocks and Alder Stream into 14. Sampling for the evaluation was allocated on the basis of these blocks. A sample was a cluster consisting of 2 trees of each species at each of 5 points in a diamond shaped pattern oriented on the cardinal directions (center, north, east, south and west). The points in cardinal directions were each about 2 chains (40 meters) from the center. In T5ND near each point, 2 hemlocks and 2 red spruces were selected, and, on a few points, 1 or 2 balsam firs.

In T5ND, one evaluation cluster was established in each of the 3 spray blocks, and one in each of 3 nearby unsprayed areas. All clusters were established in softwood stands (>60 percent conifer).

In Alder Stream, 8 clusters were established in spray blocks and 6 in nearby unsprayed areas or unsprayed areas within the spray blocks. In both spray blocks and unsprayed areas, clusters were equally divided between softwood stands (>60 percent conifer) and mixedwood (20-40 percent conifer).

A. Evaluation of Efficacy

The selected trees were sampled prespray for spruce budworm populations (larvae) and postspray for both spruce budworm populations (mostly pupae) and the extent of defoliation. A prespray sample consisted of one 18 inch branch from each tree. The postspray sample consisted of two 18 inch branches. Prespray sampling was completed no earlier than 2 days before spraying. One cluster on T5ND and 1/2 cluster in Alder Stream were sprayed before they could be sampled. These were sampled the same day they were sprayed. Prespray samples were bagged and sent to the laboratory for the larval counts. The larvae were counted within 5 days after the branches were collected. Both dead and live larvae were included in prespray counts.

Postspray samples were collected 2 weeks after spraying was completed when most of the budworm had ceased feeding (most had pupated). The budworm pupae and surviving larvae were counted, and defoliation estimated on some trees in the field. It was soon found more efficient to bag the branches and later examine them in the laboratory. Defoliation was estimated by Fettes' method, using 20 systematically chosen shoots from each branch.

For both prespray and postspray estimates, insect counts and defoliation at individual points were combined and averaged.

B. Assessment of Spray Deposit

Spray deposit was assessed at each sample point of all sprayed clusters, except for one cluster in T5ND which could not be reached in time. Three Millipore filters (47 mm diameter gridded Millepore® filters) were placed on stakes in openings between tree crowns near each point to collect the Bt spray. These were retrieved 1/2 to 12 hours after spraying and retained for later laboratory culturing. To make certain check areas had not been sprayed, whenever possible filters were also placed in unsprayed clusters, one at each of three points. To determine if needle samples could be used as a partial substitute for filters (to yield sprayed vs. unsprayed information), a twig was collected at each point.

In the laboratory, the filters were placed on petri dishes containing tripticase soy agar and incubated at 29° C for about 15 hours. The number of bacterial colonies per cm² was estimated by sampling each filter at five separate points (each four squares in area) on the gridded filter and applying the equation $\text{cm}^2 = \frac{\text{total colonies counted} \times 9.64}{17.35}$. Needle samples were cultured in a manner similar to that for filters, and for each point, the percent of needles on which colonies formed was calculated. All filters and needle samples were examined for the crystals characteristic of Bt.

Results and Discussion

Passamaquoddy Lands (T5ND). The objective of the T5ND project was to protect hemlock, but we decided to evaluate the effect of the spraying on spruce at the same time. The sample data of the T5ND project are shown in Table 1. Cluster 3, established in a block that originally was

Table 1. Prespray and postspray budworm populations and defoliation of hemlock and spruce on T5ND during the 1982 suppression project.

Cluster	Number budworms per 18" branch				Percent defoliation	
	hemlock		spruce		hemlock	spruce
	prespray	postspray	prespray	postspray		
1	26.7	0	9.4	1.2	1.0	12.5
2	5.5	0.1	8.4	0.8	1.1	15.3
3	8.1	2.9	9.8	3.2	5.6	27.8
US-1 (check)	7.5	3.4	7.4	1.8	9.2	29.5
US-2 "	14.4	7.7	17.0	2.8	13.3	48.8
US-3 "	16.0	6.0	10.5	2.4	14.6	25.9

to be entirely sprayed, apparently was not sprayed (Millepore filters were not in place in time, so we can't be certain). While the block was being sprayed, an area of hardwoods was excluded, and cluster 3 had been established near the edge of the hardwood stand. Here, Cluster 3 is considered not sprayed.

Table 1 indicates the project was very successful in reducing budworm populations on the hemlock. From the sprayed clusters, only a single larva was found on the 40 post-spray branches examined. As for the defoliation estimates, some problems in the assessment of defoliation are apparent. The survival of budworms on unsprayed clusters was apparently higher on hemlock than spruce (about 43 percent of prespray populations on hemlock compared to 23 percent on spruce, a difference significant at the 80 percent level of confidence), yet the defoliation was greater on the spruce. Our methods of estimating either populations or defoliation (probably the latter) are obviously faulty.

Table 1 indicates that the spraying had some effect on the budworm populations on spruce and subsequent defoliation, even though the buds of spruce had not yet opened at the time of spraying. This may be true (State personnel found similar results on their 1981 project) but cannot be established here, given the few clusters involved. A regression of subsequent defoliation on the prespray budworm populations of the unsprayed spruce clusters yields a good relationship ($r^2 = .895$), but the expected values for defoliation on clusters 1 and 2 (28.8 and 26.6 percent) are not significantly different from the values observed (12.5 and 15.3 percent).

Spray deposit on one of the two sprayed clusters was 19-24 colonies/cm²; on the other, 17 colonies/cm² at two points and 1-4 colonies/cm² on the other three. The differences in budworm survival or defoliation between the two clusters, and between points on the latter cluster, are slight. Probably both were adequately sprayed. The canopy, which was dense on cluster 2, could easily have shielded the filters from the spray. Three filters were placed on one unsprayed area. The filters received 1 colony/cm², apparently due to drift.

Penobscot lands (Alder Stream). Insect survival and tree defoliation in the Alder Stream Township are shown in Table 2. It was intended that Block 14 (Cluster 14-M) be sprayed, but it fell in an "out" created while the spraying proceeded. Thus, it is included in the checks. Another cluster in Block 2 was not included here because we are not certain whether it was sprayed or not. Mean percent defoliation on sprayed clusters was 1.5 compared to 3.4 percent on the unsprayed. Because the trees could have been defoliated up to 65 percent without significant harm, the difference is of little practical interest, even if it were

statistically significant (it is not). Budworm survival was low in both sprayed and unsprayed clusters, averaging 0.3 (6 percent of the prespray population) and 0.2 (11 percent of the prespray population) budworms per 18" branch. A regression of defoliation on prespray populations yields a rather poor relationship ($r^2 = .67$) and the spraying cannot be shown to have been effective in reducing budworm populations. Survival of prespray populations on sprayed areas averaged 6.3 percent compared to 11.2 percent on unsprayed areas, a difference that is not statistically significant.

Table 2. Prespray and postspray populations and defoliation of spruce, Alder Stream suppression project, Maine, 1982.

Cluster	No. budworms/18" branch		Percent Survival	Percent defoliation
	prespray	postspray		
A-2-S	0.4	0.0	0.0	0.1
A-6-S	4.2	0.8	19.0	3.3
A-6-M	4.7	0.4	7.4	3.1
A-8-M	1.2	---	---	0.1
A-10-S	4.7	0.4	7.4	1.7
A-11-M	3.2	0.1	1.6	0.1
A-12-S	<u>6.5</u>	<u>0.2</u>	<u>2.3</u>	<u>2.0</u>
Average	$3.55 \pm .81$	$0.28 \pm .12$	6.3 ± 2.8	1.49 ± 0.53
A-14-M (check)	2.5	0.2	3.1	2.7
A-US-S-1 "	2.6	0.4	8.3	5.6
A-US-S-2 "	4.8	0.2	7.1	4.5
A-US-S-3 "	0.7	0.1	10.4	1.7
A-US-M-1 "	1.2	0.3	13.5	3.2
A-US-M-2 "	<u>0.6</u>	<u>0.1</u>	<u>25.0</u>	<u>2.7</u>
Average	$2.07 \pm .65$	$0.19 \pm .05$	11.2 ± 3.1	3.40 ± 0.58

The results of the spray deposit assessment are in Table 3.

Table 3. Spray deposit on sprayed and unsprayed clusters, Alder Stream.

Cluster	Spray deposit (colonies/cm ²) on 5 points each cluster				
	C	N	E	S	W
A-2-S	4	4	3	106	4
A-2-M	33	24	24	41	19
A-6-S	36	41	56	27	44
A-6-M	14	52	25	4	26
A-8-M	9	6	7	33	24
A-10-S	22	43	47	25	34
A-11-M	67	79	89	140	119
A-12-S	39	16	22	33	82
A-14-M (check)	1	1	0	1	0
A-US-S-1 "	0	0	3	0	4
A-US-S2 "	2	0	3	2	0
A-US-S-3 "	7	3	11	6	3
A-US-M-1 "	3	0	2	0	3
A-US-M-2 "	6	0	6	0	10
A-US-M-3 "	6	0	6	0	5

The data indicate that several points on clusters A-2-S and A-8-M, and one point on cluster A-6-M, may not have been sprayed. However, the filters could have been shielded from the spray by foliage. On some points the deposit is very high, indicating the clusters may have been sprayed more than once. Expected deposit is 15-30 colonies/cm². Here

8 of 40 points had deposits above 50 colonies/cm². For these and perhaps other reasons, a relationship between spray deposit and budworm survival or defoliation cannot be established.

The test for the use of needles as a substitute for the filters did not show promise as an assessment method, either here or in T5ND. The proportion of needles with colonies on sprayed clusters was .95 compared to .76 on unsprayed clusters, a difference that is not statistically significant. The method showed promise in the Maine 1980 project, and we don't know why such a large proportion of the unsprayed needles had colonies of Bt. The twigs were carried to the lab in envelopes, so it is possible that a few needles with deposits from drift contaminated other needles within the envelopes.

Conclusions

The October, 1981 biological evaluation of budworm populations on the Passamaquoddy Lands, T5ND, accurately predicted high populations for 1982. Thus, the decision to spray was a sound one, and the evidence we have indicates the project was reasonably well conducted. One of the three clusters was not sprayed, but apparently this was due to a late change in the area to be sprayed. Spray deposit was, in general, good, and if the two sprayed clusters are representative, the spraying reduced budworm populations on hemlock almost to zero.

As mentioned earlier, our method of estimating defoliation of hemlock apparently grossly underestimated the defoliation. Still, the comparison of sprayed and unsprayed branches should be valid if the same, albeit faulty, method is used for both. Defoliation on the two sprayed clusters

was about 1 percent and on unsprayed clusters, from 9 to 15 percent. Unfortunately the prespray budworm population on the hemlock of one sprayed cluster was very high - 26.7 larvae/branch. On the other sprayed cluster, the prespray budworm population was only 5.5 larvae/branch. Both these estimates fall outside the range of prespray populations on the unsprayed clusters (7.5 - 16 larvae/branch). Thus the comparisons of defoliation on unsprayed clusters with values that could be expected on sprayed clusters if they had not been sprayed (21 and 8 percent, arrived at by regression) are largely conjectural. Clearly more clusters were needed, but the available personnel could not establish them within the time limits. Perhaps the establishment of smaller clusters is a workable alternative, and within cluster variation should be analyzed with this end in view. More clusters, and an acceptable method of estimating defoliation of hemlock, would improve future evaluations.

The Penobscot (Alder Stream) Project apparently reduced budworm populations but larvae survival was so low on both sprayed and unsprayed plots, that the results may not be indicative of a typical project. The defoliation estimates are even less helpful.

The operational phases of the project were well conducted, though spray deposit data suggest aircraft guidance was a problem. Spray deposits in swath overlaps could reach 50 colonies/cm² or so, but deposit exceeded 50 at 20 percent of the points. Another 20 percent of the points had low deposit. Spray deposit may be low because of screening by foliage, and high because of air movement or other micrometeorological effects within the forest canopy. If we assume neither factor was important, our data would suggest roughly 80 percent application efficiency.

However well the project was conducted, the data indicate that the defoliation that would have occurred, had there been no spraying, was insignificant. Part of the difference between the defoliation expected and what occurred is due to unexplained budworm mortality. The budworm populations, in the moderate range on most clusters before spraying, had dropped far more than expected by the time the postspray samples were taken. This drop occurred in unsprayed clusters, and presumably would have in sprayed clusters. Survival of prespray larvae to postspray on unsprayed areas was only 11 percent compared to 24 percent on the T5ND project. Such declines in populations cannot be predicted by currently available methods.

However, even if there had been no unusual decline, the hazard to the spruce posed by the prespray budworm population was probably overestimated. The factors responsible for overestimating the hazard were the inadequacy of existing evaluation methods and poor access to the stands. To elaborate:

1. The biological evaluation did not take elevation into consideration. Alder Stream Township is a mountainous area, ranging in altitude from 1200 feet to nearly 4000 feet above sea level. Because there was little time to complete the evaluation before the information was needed, sampling was limited to the more accessible areas - the valleys at lower elevations. These samples indicated moderate budworm populations (based on threat to fir) but a hazardous situation for the trees because of past defoliation. The later prespray populations in the lower areas (clusters A-6-S, A-6-M, A10-S, and A-12-S) were indeed in the moderate range. At the higher elevations, the prespray populations were lower. In the Canadian Forestry

Service's pamphlet "Guidelines for Predicting Tree Mortality Caused by the Spruce Budworm, and Measures for Reducing Losses" recently published, it is stated that damage is less at elevations above 700 m (2300 ft.) and at lower elevations, trees in valleys are often damaged more severely than those on hilltops.

2. The budworm populations that form our criteria for regarding a population as "low", "moderate" or "high" are based on the threat to fir, not spruce. On fir, prespray larvae populations of 10 larvae/18" branch are usually considered high. The equivalent number for spruce is not known. Spruce has considerably more foliage than fir, but the resistance of spruce to damage may not be proportionate.

3. The biological evaluation overestimated the hazard to spruce of another defoliation. The fact that elevation was not considered was responsible for much of this underestimation, but more important was the fact that the past damage to fir as well as spruce went into the equation for the hazard rating. The fir apparently brought the rating into the high category. A later assessment, using the postspray samples from spruce, indicated only light to moderate 1981 defoliation in most areas.